Helios Mission Support

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This article describes ongoing Deep Space Network support of the Helios 1 spacecraft. In addition, planning for a Solar Corona Faraday Rotation Experiment during the December 1981 14th Helios 1 perihelion and subsequent solar conjunction phase is detailed.

I. Introduction

The Helios Mission, a cooperative effort of the Federal Republic of West Germany and the United States of America, was initiated to study the properties of the Sun via spacecraft measurements at close range. Two Helios spacecraft were launched; Helios 1 on December 10, 1974 (Ref. 1) and Helios 2 on January 15, 1976 (Ref. 2). Helios Mission support through 1978 was regularly documented in the TDA Progress Report (Ref. 3). On March 21, 1980, the Helios 2 spacecraft suffered a failure of the traveling wave tube amplifier, and (essentially) no useful data could be salvaged, although periodic attempts to communicate with and acquire data from Helios 2 were made until January 8, 1981, at which time the spacecraft transmitter was commanded off. On the other hand, the Helios 1 spacecraft continues in reasonably good health, and has been regularly in communication with the Deep Space Network (DSN) until the present time. This article describes recent DSN support of Helios 1, and, in particular, describes planning for a December 1981 Helios 1 Faraday Rotation Experiment.

II. Helios 1 Support

During 1981, Helios 1 was supported by the German Weilheim tracking station, and by (primarily) the 26-m DSN stations at Goldstone, California (DSS 11) and Honeysuckle Creek, Australia (DSS 44). During this period, important inner solar system science data were generated by onboard Helios 1 science instruments. In turn, these data are being correlated with science measurements from other spacecraft, such as the Voyagers, Pioneers, and ISEE-3, to further study such topics as the modulation of cosmic radiation with solar cycle, the observation of coronal mass ejection events from the solar limb, and the triangulation of Types III and IV solar events (Ref. 4). During 1981, which is marked by the beginning phase of the decline of solar activity during the 21st solar cycle, interesting phenomena observed in Helios 1 science data included magnetic bubbles, short periods of rapid decline in solar wind intensity, and the appearance of simple ionized helium (Ref. 4).

The 12th perihelion of Helios 1 occurred on December 12, 1980, and the 13th on June 13, 1981. The 14th perihelion passage will occur on December 20, 1981, with a solar conjunction phase immediately thereafter, and this opportunity will be utilized to perform a Faraday rotation radio science experiment with the Helios 1 signal and the DSN 64-m subnetwork.

III. Faraday Rotation Measurements in the Solar Corona

In November 1968, the Pioneer 6 spacecraft was occulted by the Sun. The Pioneer 6 spacecraft transmitted a linear polarized carrier, which allowed the first experiment to be performed using a man-made signal source in determining Faraday rotation through the solar corona (Ref. 5). The quasilongitudinal approximation for Faraday rotation is given by (Ref. 6):

$$\Omega = Qf^{-2} \int N_e B_l dR$$

where

Ω = Faraday rotation, deg

f = signal carrier frequency, Hz

Q = 1.3548×10^6

R = signal path, m

N_e = electron density, m^{-3}

B_l = solar longitudinal component of magnetic field, tesla

Therefore, measurement of coronal-induced Faraday rotation provides information about both electron density and the solar magnetic field (Ref. 7). To support this class of experiment, the 64-m subnetwork was equipped with remotely rotatable, microwave linear feeds (Ref. 8). Closed-loop polarimeters (Ref. 9) were implemented and are used to automatically measure the orientation of the received signal polarization. This system maximizes the received signal strength and yields precise signal polarization angle data.

Research using the polarization measurement capability at DSS 14, 43, and 63 continues with the Helios spacecraft; Volland et al. (Ref. 10) and Bird et al. (Ref. 11) have reported Faraday rotation observations from the solar occultations of Helios in 1975. More recently, Dennison et al. (Ref. 12) have expanded on these results with a measurement of the gravitational deflection of polarized signal radiation propagating through the solar corona.

IV. Helios 1 Faraday Rotation Experiment Planning

In previous Helios Faraday rotation experiments (Refs. 10, 11, 12), heavy coverage requirements of other flight projects prevented the Helios Project from obtaining continuous coverage during the experiment period, causing sizeable gaps in the data and thereby somewhat hampering scientific analysis and interpretation of the data because of possible 180° ambiguities. In the upcoming 14th perihelion passage and subsequent solar conjunction, the geometry is such as to cause the solar conjunction phase to be compressed into a rather short period; Figs. 1, 2, and 3 detail the perihelion passage and subsequent solar conjunction geometry. In addition, total flight project coverage requirements on the 64-m subnetwork during December 1981 are light by historical standards. The fortuitous combination of these circumstances allowed Helios 1 to obtain nearly continuous scheduled coverage on the 64-m subnetwork from day of year (DOY) 353 at an ingoing Sun-Earth-Probe Angle (SEP) of 4.1 degrees, to DOY 359, at an outgoing SEP angle of 3.8 degrees. The schedule of tracks planned at the 64-m subnetwork in support of this experiment are listed in Table 1. Demonstration passes for this experiment were conducted as follows:

DSS 14: DOY 344 and 348
DSS 43: DOY 338 and 339
DSS 63: DOY 335 and 337

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Table 1. Planned Helios 1 64-m subnetwork coverage

Day of year, 1981	DSS	Pre-calibration, Z	Post-calibration, Z	Acquisition of signal, Z	Loss of signal, Z
352	43	16:55	08:40	19:05	08:10
353	63	08:00	16:20	09:30	15:50
353	14	13:15	00:00	15:15	23:25
353	43	22:15	08:50	23:45	08:20
354	63	06:45	16:25	08:15	15:55
354	14	13:25	00:15	15:25	23:45
354	43	17:20	08:50	19:20	08:20
355	63	06:50	16:30	08:20	16:00
355	14	13:35	18:30	15:35	18:00
356	63	10:00	16:40	12:00	16:10
356	14	13:40	00:35	15:40	00:05
356	43	17:30	09:10	19:30	08:40
357	63	06:35	16:30	08:35	16:15
357	14	13:45	00:50	15:45	00:20
357	43	17:40	09:20	19:40	08:50
358	63	06:40	16:50	08:40	16:20
358	14	13:50	00:50	15:50	00:20
358	43	22:20	09:25	23:50	08:55

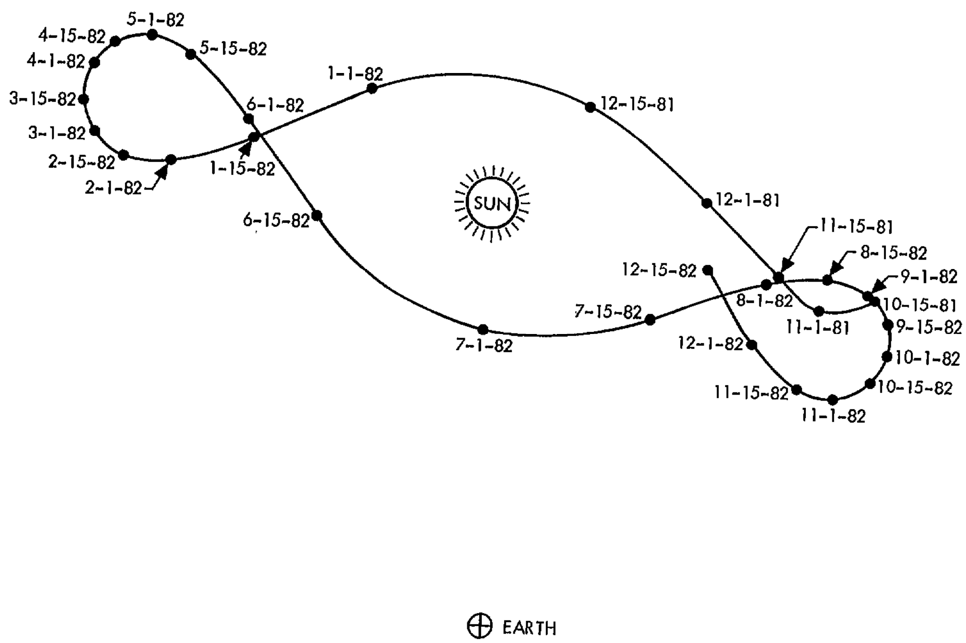

Fig. 1. 1981–1982 Helios 1 position in the ecliptic plane assuming a fixed Earth-Sun line

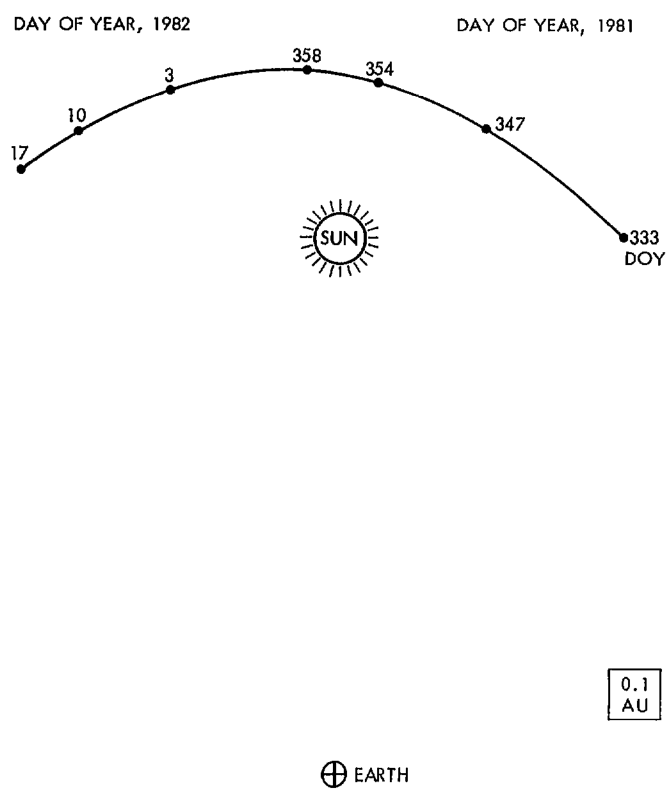

Fig. 2. 14th perihelion and subsequent solar conjunction phase of Helios 1 in the ecliptic plane assuming a fixed Earth-Sun line

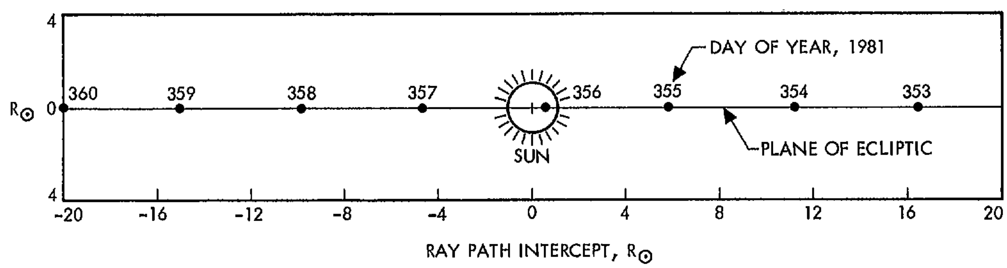

Fig. 3. Solar conjunction phase of Helios 1 ray path intercept in the plane perpendicular to the ecliptic plane and Sun-Earth line